EXHIBIT A

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UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF DELAWARE

ART+COM Innovationpool, GmbH., Plaintiff, vs. Google, Inc., Defendant.	C.A. No. 14-cv-217-RGA **EXPERT REPORT OF KENNETH R. CASTLEMAN, PH.D. REGARDING INFRINGEMENT OF U.S. PATENT NO. RE44,550**

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IV. TUTORIAL AND BACKGROUND OF THE TECHNOLOGY

I expect to provide testimony regarding the background of the industry and technology related to the ‘550 Patent.

A. The Evolution of Digital Imaging

As early as 1957, scientists were experimenting with processing photographic images on a computer (R. A. Kirsch, et. al., “Experiments in Processing Pictorial Information in a Computer,” *Proceedings of the Eastern Joint Computer Conference*, Dec. 9, 1957). In the 1960s, that research was centered mainly in the large government laboratories (e.g., NASA-JPL). *See, e.g.*, K. R. Castleman, *Digital Image Processing*, Prentice-Hall, 1979. In the 1970s, several major universities began to contribute to the technology development, notably USC and the University of Utah. By the 1980s, industrial companies were bringing high-end digital image processing products to market. Today digital imaging is firmly embedded in television broadcasting, movies, cameras, smart phones, and a variety of other industrial and consumer products as well.

In the 1970s, there was a split in the development between digital image processing and computer graphics. While digital image processing (e.g., NASA-JPL, USC) was concerned with enhancement and analysis of images taken by cameras and other imaging devices, computer graphics (e.g., University of Utah) focused on displaying images of 3D objects that exist only as a mathematical description. The two fields came back together somewhat in the 1990s when it became common to “wrap” a two-dimensional image around a 3D graphics object. The technology at issue in this case is of that same ilk.

B. Art+Com and its Terravision Development

The named inventors on the ‘550 Patent (Mayer, Schmidt, Sauter, and Gruneis), working at Art+Com, developed a geospatial data display system and reduced their invention to practice in connection with their work on a medium called “Terravision.” The system presents a networked virtual representation of the Earth based on satellite images, aerial photography, and altitude and architectural data. In addition to photorealistic representations of the Earth,

Terravision displays historical and architectural data, which allows users to navigate not only spatially but through time. Terravision was the first system to provide a seamless navigation and visualization in a very large spatial data environment.

On December 17, 1996 the inventors filed a U.S. patent application that issued on August 8, 2000 as U.S. Patent No. 6,100,897. It was reissued on July 13, 2010 as U.S. Patent No. RE41,428. It was reissued on Oct. 22, 2013 as US Patent No. RE44,550 ("the '550 Patent"). The '550 Patent is entitled "Method and Device for Pictorial Representation of Space-Related Data."

C. Google's Development

Art+Com implemented the Terravision system on high-end computer graphics display equipment manufactured by Silicon Graphics, Inc. (SGI), at times working with SGI engineers in the process to ensure that both the hardware and the low-level graphics software libraries were adequate to support the Terravision system. SGI personnel who were familiar with Terravision left SGI and went to work for Intrinsic Graphics. In 2001, a company called Keyhole, Inc. split off from Intrinsic Graphics and developed a graphical geospatial data visualization system called "Earth Viewer." In 2004 Google acquired Keyhole and, in 2005, Google released its own geospatial data visualization system called "Google Earth." In the early part of 2014, Google released a new version of Google Maps for Desktop that included Earth functionality (hereinafter "Google Maps with Earth").

D. Displaying Space-Related Data

Terravision, Google Maps with Earth, and Google Earth all work in the following way. The Earth is modeled as a sphere, and locations on the surface are specified by longitude and latitude. At any point in time, the user specifies a point above the Earth from which to view the planet. Points above the Earth are specified by their altitude above the surface and the latitude and longitude of the point directly below. If the specified altitude is large enough, the entire planet will be in view. At lower altitudes, only a rectangular region on the surface will fill the display screen.

Once the location of the viewing position has been established, the user can specify the

direction of view. For example, the program might begin with north at the top of the screen ("looking north"). The user can rotate the angle of view to another compass heading (e.g., "looking west") so that another compass direction is at the top of the screen. Finally, the user can specify an angle of view. Instead of looking straight down at the planet, one can specify, for example, looking west with a line of sight that makes a 45 degree angle with the vertical.

The view of the observer is modeled in software as a "virtual camera," which is common in computer graphics. Once the five typical viewing parameters for the virtual camera (latitude, longitude, altitude, compass heading, and viewing angle) have been established, the software determines which area on the Earth's surface would be visible to such an observer. It does this by extending a truncated pyramid ("frustum") out from the viewing position and calculating where that frustum intersects the Earth. The four sides of the frustum represent the top, bottom, left, and right edges of the display screen. This step is important because the viewing frustum is used to efficiently determine which image data must be downloaded from the servers and displayed.

Given the area of the Earth's surface that is to be displayed, the system sends out requests to the servers for the required image data. The servers respond by sending back images of the Earth that were taken in that area. The position of each of those images on the Earth is referenced by latitude and longitude. The software running on the local computer fits the received images together to form a larger image that fills the display screen. Other data can be downloaded and overlaid on the displayed image as well. This includes roads and rivers, topographical data (hills and valleys), and signs and markers.

The image data on the servers is stored in several different resolutions. Some of the images cover a wide area with pixels that are located far apart on the surface (low resolution). Other images cover a smaller area with closely spaced pixels (high resolution). The local computer determines which resolution is required to match its display screen. This will depend on the altitude of the viewing position. At high altitudes, low resolution images are needed to cover the large area that is visible to the observer. As the altitude is decreased, higher resolution images must be downloaded to fill in the details that become visible. The way in which this is

implemented is one of the major innovations of the '550 Patent and a key element in making these systems practical on today's computers and smart phones.

Software designers use an organizational concept known as a "data structure" to identify each item of data and to keep track of where each item of data is stored. The data structure specified in the '550 Patent, and used by Google, is known as a "tree structure." The tree is made up of "nodes" that contain data. Each node resides on a branch of the tree. Most nodes have two or more branches splitting off from them. The splitting of the tree branches defines the hierarchy of the data structure. In order to locate a particular item of data, the software "traverses" the tree. This means it follows the branches from node to node to examine relevant data that is conceptually stored in the tree.

The images stored on the servers can be conceptually arranged in a hierarchical structure known as a "quad tree." Each image has four "child" images, each of which covers one-fourth of the area that is covered by the "parent" image. Together, the four children cover the same area as the parent, but with twice the resolution (i.e., with pixels half as far apart on the surface). As the user specifies lower and lower altitudes, the system replaces parent images with child images, and smaller and smaller detail becomes visible. At high altitudes, one might be able to see all the houses in a neighborhood, but very little detail on each house. At a lower altitude, one might see only one house, but be able to resolve individual shingles on the roof. This facility is implemented by continuously downloading new child images from the servers and using them to replace their parent images in the display. Once downloaded, the images are stored in a cache memory in case they might be needed again if, for example, the user should "zoom out" by increasing the viewing altitude.

This process would be straightforward to implement on a large mainframe computer where speed of response is not important. It is the high efficiency of the implementation disclosed in the '550 Patent that makes this facility possible on desktop computers and smart phones. I am aware of no substantially different implementation that would allow a smart phone user to view the Earth with the speed and convenience of Terravision or Google Earth.

V. U.S. PATENT NO. RE44,550

U.S. Patent No. RE44,550, entitled "Method and Device for Pictorial Representation of Space-Related Data," issued on October 22, 2013. The '550 Patent is a reissue of U.S. Patent No. RE41,428 ('428 patent) which is a reissue of U.S. Patent No. 6,100,897 ('897 patent). I have reviewed the specification, claims, and file history of the '550 Patent.

The '550 Patent describes and claims an invention that has been reduced to practice in a medium called "Terravision." Terravision is a networked virtual representation of the Earth based on satellite images, aerial photography, and altitude and architectural data. It provides an environment to organize and access information spatially. Users of Terravision can navigate seamlessly from overviews of the Earth to extremely detailed objects and buildings. In addition to photorealistic representations of the Earth, Terravision displays a variety of other data, including historical photographic and architectural data, which allow users to navigate not only spatially but through time as well. All data are distributed and networked and are streamed into the system in response to the user's needs. Terravision was the first system to provide a seamless navigation and visualization in a very large spatial data environment.

A. Description of the Preferred Embodiment

The '550 Patent describes a method and device for the pictorial representation of space-related data, for example, geographical data of the Earth. Space-related data (e.g., satellite images and aerial photographs; topography; maps of roads, rivers and borders) are called up from servers that are geographically distributed on a network, and the data are stored at the user's location. The local hardware then generates a screen representation of the object as seen from the user-specified location and field of view of a virtual observer. During the process, the required data are called up from distributed data sources on the network (e.g., servers) and displayed to the user in real time. Multiple images of the object are fitted together to form an image large enough to fill the display screen. Although data may exist on the servers in multiple resolutions, only data at the resolution required to create the selected view are transferred to the user's location.

When the user "zooms in" by moving the virtual viewpoint closer to the object, higher resolution data are requested of, and received from, the servers. In so doing, the image sections that make up the currently displayed screen are subdivided according to the method of a binary or quadrant tree. The result of this approach is a data transfer and processing efficiency that makes possible real-time examination of an object as complex as the Earth using readily available computer equipment at the user's location.